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XVI.—*On the Reproduction of Lost Parts in the Articulata.* By George Newport, F.R.S. &c.

[With a Plate.] See opp p 95

The reproduction of lost parts in animals is an occurrence of great interest to the physiologist, when considered with reference to the function of nutrition, or with regard to the manner in which the external parts of the body are originally formed. It is desirable, therefore, that we should carefully record every fact that can in any way assist us in explaining the phænomena connected with it, or that tends to verify its occurrence in any particular class.

Naturalists, for a long series of years, have been aware that the Crustacea and Arachnida have a power of reproducing their limbs when the original ones have been accidentally lost or removed, but, until a somewhat recent period, this power was believed to be confined almost entirely to those two classes of the Articulata. It was believed that true insects were not endowed with it, or at most but to a very slight extent.

Beckmann formerly noticed the existence of a leg of diminutive size in *Agrion virgo* *, and Goeze a similar one in *Semblis bicaudata* †; whence the latter naturalist concluded that these were parts which had been reproduced. But no experiments whatever seem to have been made by him, or by any other naturalist, so far as I am aware, to test the question as to whether true insects possess the power of reproducing lost parts, until those which were made by Dr. Heineke ‡. This gentleman's observations however were imperfect, as they were made only on the antennæ of *Blatta* and *Reduvius*. The antennæ of these species were reproduced, but no experiments were made on the legs.

* Physikalisch-œkonomische Bibliothek, vol. iii. p. 20.
† Naturforscher, par. xii. p. 221.
‡ Zoological Journal, vol. iv. p. 422.

Dr. Burmeister indeed, in 1836*, made a general vague statement that mutilated caterpillars are said to obtain new limbs, but his remark was not accompanied by any reference to experiments in support of the fact; while he remarked of insects generally, that they "display but very slight traces of a power of reproduction." Subsequently to this, Professor Müller, in the excellent English edition of his 'Physiology' by Dr. Baly in 1837, stated that the larvæ of insects reproduce their antennæ, and that those of *Phasma* also reproduce their legs†. No observations had yet been made to show that any of the Myriapoda possess this power, until a specimen of *Scolopendra subspinipes* with the eleventh leg on the left side extremely diminutive, was exhibited by myself at a meeting of the Entomological Society in November 1839, and pointed out as an instance of reproduction in that class. In the following February the Rev. F. W. Hope exhibited an Australian *Scolopendra* with one of the posterior legs very diminutive, and which, with me, he regarded as a structure that had been reproduced. This view was strongly objected to by Mr. J. Obadiah Westwood, the entomologist, who contended that these were only instances of retarded development; and he maintained this opinion with much perseverance. In November 1840 the same gentleman produced to the Society, in support of his assumption, a specimen of *Lithobius* with a diminutive posterior leg, which he regarded as an instance of retarded development, and not as one of reproduction.

As the promulgation of erroneous opinions is a matter of serious import to science, more especially when sheltered by apparent facts, I endeavoured to put these opinions and my own views to the test of experiment. Accordingly, I instituted a series of experiments on the Myriapoda, both on the Chilognatha in 1841 and on the Chilopoda in 1842. These most fully verified my formerly expressed belief. The *Iulidæ* and *Lithobii* were both found to possess the power of reproducing their antennæ and legs. This was proved to be most extensively possessed by the very young animal, in which the legs can be reproduced even a second time. The first of these experiments in 1841 were witnessed by my friend Mr. Waterhouse, and this gentleman bore testimony to the facts at a meeting of the Entomological Society in January 1844 when I announced them‡, on the occasion of the reading of some observations by Mr. Fortnum on the reproduction of a limb, observed by himself in *Phasma*. On that occasion I also pointed out the fact, that the armature of spines, &c. on reproduced limbs is almost always imperfect, and often

* Manual of Entomology by Shuckard, 1836, p. 427.

† Elements of Physiology by Baly, vol. i. p. 405, 1837.

‡ Ann. and Mag. Nat. Hist. vol. xvi. p. 274.

entirely absent; a fact which Mr. J. Obadiah Westwood afterwards * quietly re-announced without due acknowledgement. Mr. Waterhouse's testimony in support of my facts has also been most strangely omitted by Mr. J. O. Westwood, the Secretary, in his printed report of that meeting †, notwithstanding that Mr. Waterhouse's confirmation was duly entered in the Minute Book of the Society. Mr. Westwood however still doubted that the fact was common to the whole class of insects.

Mr. Fortnum's observations on *Phasma* confirmatory of the statement by Müller, together with Heineke's on the antennæ of *Blatta* and *Reduvius*, and an observation then made by Mr. Marshall, that he had once observed a specimen of the common *Blatta* with one leg much smaller than the rest, were regarded by Mr. J. O. Westwood as showing only a power of reproduction in those insects which do not undergo a complete metamorphosis; and on a subsequent occasion ‡ he endeavoured to draw a distinction between these, and those which do undergo such change, and announced his belief that the Lepidoptera are incapable of reproducing lost parts.

With a view to set this question at rest, as I had already set at rest that respecting the Myriapoda, I made a series of experiments in the following summer on the larvæ of two of our commonest Lepidoptera, *Vanessa urticæ* and *V. Iö*, the nettle and peacock butterflies. The results of these were perfectly confirmatory of the general view, and established the fact, that a power of reproduction of lost parts is common to the whole of the Insecta. The observations on *V. urticæ* were communicated to the Royal Society on the 20th June 1844, and are printed in the 'Transactions' for that year. An account of these experiments was also given a few months later, and the specimens exhibited to the Entomological Society in October 1844, at which time Mr. H. D. S. Goodsir also gave an account of his own experiments on the Crustacea.

Thus then these experiments have established the fact as a law, that the whole of the Articulata have the power of reproducing lost parts. Every new observation on the growth of parts confirms this view. Very recently I have received, in a collection of insects from Melbourn, Port Philip, a specimen of *Panesthia*, one of the *Blattidæ*, in which the metathoracic leg on the left side has been reproduced. The entire limb is not more than one-third of that of the corresponding one on the opposite side, but, as in the insects experimented on, it possesses the whole of the essential parts of the organ—the coxa,

* Ann. and Mag. Nat. Hist. vol. xvi. p. 277. † *Loc. cit.* 274.

‡ Proceedings Ent. Soc. March 1844; Ann. and Mag. Nat. Hist. vol. xvi. p. 277.

femur, tibia, tarsus and claw, as well as rudiments of spines (Pl. VIII. fig. 2). It thus agrees precisely with the new limbs produced in Lepidoptera. I have found in every instance in my experiments that all the primary or essential parts of a limb exist when the new organ first makes its appearance; but that its secondary parts, as, for instance, the armature of spines and the joints of the tarsus, are later in their formation. The joints of the tarsus usually are fewer in number in new limbs that have not attained the normal size than in the original limbs. This is invariably the case when the limb is first produced. As the entire organ continues to grow, the tarsus becomes more and more elongated, proportionately to the other parts; and when the insect next changes its tegument, the number of joints to this part of the limb is increased by the production of a new joint at the distal extremity of the penultimate one, interposed between it and the joint which bears the claw; precisely as new segments are added to the body of the Myriapod, between the last newly-produced segment and the caudal, or penultimate, at each change of its covering. It is in this way also that new joints are developed in the antennæ of *Lithobius*, always at the distal margin of a preexisting joint, only that in this case the new part is formed at the distal end of each previous joint.

In the specimen of *Panesthia* above alluded to, there are only three joints to the tarsus, instead of five, besides the unguis. Of these, the basilar or true tarsal joint, as in the perfect limb, is the longest, so that those joints which are nearest to the body are always, at first, most quickly enlarged and elongated. Thus, as the growth of the whole limb proceeds, first the femur and next the tibia become proportionately elongated, and lastly the tarsus and its subdivision into joints. This is a fact of some importance in a comparative anatomical and zoological point of view, because it shows that an increased number of tarsal joints amongst true insects is not a proof of inferior development.

The immediate source of origin of the new limb is extremely difficult to ascertain. My own experiments on Lepidoptera, and Mr. Goodsir's on the Crustacea, lead to the belief that the new limb has its origin in a little, elevated, central point, beneath the cicatrix which covers the surface of the space to which the old limb was attached; and that within this little elevated point, as within a capsule, the microscopic rudiments of the new limb are formed. Mr. Goodsir's observations on the Crustacea seem to show that even at this early period the limb is formed of distinct articulations; but recent observations made by myself on the original formation of the limbs in the *Chilopoda* and in the *Forficulidæ* have led me to believe that this is not the case in the earliest state of the limbs in the Myriapoda and in these insects,

but that commencing as little tubercles they are first elongated to some extent, and that their division into joints takes place at a subsequent period.

No reproduction of limbs is manifest until the period of change of tegument. Nor does the growth of a newly-formed limb continue apparent after the first few hours or day subsequent to a deciduation of tegument, when the new covering has become consolidated. The further enlargement of parts is then arrested until the next change. If a limb is lost by the young insect early in life, the newly-produced one grows more rapidly at each change, and ultimately acquires the same size and same number of joints as the normal limb on the opposite side of the body. If, on the contrary, the insect has approached to within one or two changes of its perfect state, then the new part never attains to the adult size or number of joints.

There are many circumstances which greatly influence the production of new parts. The chief of these are—the temperature and hygrometric state of the atmosphere, and the health, and quantity of nourishment supplied to the animal. If the temperature of the season is below the average height, or the atmosphere be loaded with an excess of moisture; or the insect weak and unhealthy, or not supplied with a proper quantity of food, the experiment, usually, will fail. Under the first of these circumstances the insect often dies from exhaustion from loss of blood, owing to the coagulation of effused blood not taking place; in the latter they have not sufficient power to undergo the change. Healthy insects, in a proper temperature of the atmosphere, usually begin to take food in large quantities soon after the hæmorrhage consequent on the excision of the old limb has ceased. A greater quantity of nourishment seems always to be required in the reparation of every severe injury or lesion of structure; as every severe injury always more or less retards, although it does not necessarily prevent, the usual changes. These circumstances are operative to a greater or less extent in different species of insects. Thus some species undergo their changes at a much lower average temperature than others. The common nettle butterfly, on which my first experiments were performed, undergoes its changes at a lower temperature than the peacock, *V. Iö,* the subject of my second set of observations. *Vanessa urticæ* is in general from thirteen to fourteen days in the pupa state, at a mean highest range of temperature of from 55° F. to 60° F; but the same insect undergoes its changes in from eight days and a half to nine or ten days in a temperature of from 70° F. to 75° F. The peacock butterfly, *Vanessa Iö,* requires naturally a higher temperature for its development than *V. urticæ*; it comes forth, as is well known, later in the season and nearer midsummer. It usually is fully

fourteen days in chrysalis at the seasonal temperature. The specimens bred by myself were developed in somewhat more than ten days, when the mean of the lowest temperature during that period was 71°·06 F. and the highest 75°·5 F.

In conformity with this, I found that *V. urticæ* is the best species for experiment, owing to its not requiring so high a temperature for development. On Plate VIII. fig. 3 is represented one of the specimens of *V. Iö* which were the subjects of experiment. It has the left mesothoracic leg reproduced precisely in the same stage of development as the new limb in *Panesthia*.

EXPLANATION OF PLATE VIII.

Fig. 2. Inferior surface of *Panesthia* ——? (magnified two diameters) with the left posterior leg reproduced.

Fig. 3. Inferior surface of specimen of *Vanessa Iö*, from which the left mesothoracic leg was removed at the end of the fourth change of the larva.

XVII.—*Notes on* Buccinum undatum. By Albany Hancock, Esq.

During a short residence at Cullercoats in 1841, I paid some attention to the various forms of *Buccinum undatum*, with the view to determine whether the several reputed species of this protean shell should retain the rank to which they have been elevated by some naturalists, or be reduced to mere synonyms.

In furtherance of this object I collected extensive suites of the different varieties, and soon ascertained that there are three well-marked forms, which on this coast at least do not appear to run into each other, and which are procured from distinct localities and from different depths of water. These three forms are distinguished from each other by their general shape and habit, and not merely by the undulations and striæ, characters of little importance in this portion of the genus, and on which conchologists have placed too much reliance. In all the three varieties the undulations and striæ are very variable; the form of the mouth and columella, however, is constant throughout, never losing the essential characteristics, which are retained in the most robust and coarsely undulated as well as in the most delicate and smooth.

At first I was inclined to think it probable that these three varieties might prove to be distinct species; but after a lengthened and careful investigation I feel satisfied that they are mere varieties, though of permanent and strongly-marked characters, resulting from locality and depth of water. The animals of these three varieties do not appear to vary.

It is evident from what has been said respecting the undula-